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# INSTRUCTIONS FOR THE USE OF THE O.P.L. OPTICAL DIVIDER

Table of Divisions, from 2 to 200





**Translation of:** "Diviseur Optique O.P.L. Notice d'emploi. Table des Divisions de 2 a 200." Undated brochure. No author given.

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Levallois-Perret, France, Optique et Precision de Levallois

INSTRUCTIONS FOR THE USE OF THE O.P.L. OPTICAL DIVIDER /1

Table of Divisions from 2 to 200

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Description and Instructions for the Use of the O.P.L. Divider

SPECIFICATIONS FOR THE O.P.L. OPTICAL DIVIDER /3

| | |
|---|---|
| Height of the centers | 150 mm |
| Spindle bore | Morse cone No. 4 |
| Spindle inclination angle | -5° to +90° |
| 1 division of the inclination vernier equals | 1' |
| 1 division of the spindle drum equals | 1° |
| 1 division of the micrometer dial equals | 1' |
| 1 division of the micrometer vernier equals | 5" |
| Angle of inclination of the accessory center | -5° to +11° |
| Height adjustment of the accessory center | ±18 mm |
| Precision of the divider: Maximum overall error | 15" |

Weights:

| | |
|---|---|
| Divider alone | 50 kg |
| Accessory center | 13 kg |
| Other accessories | 12 kg |
| Total weight with case | 110 kg |

GENERAL REMARKS

The standard divider for use with a machine tool consists essentially of a spindle on which a hollow wheel is secured. The latter is driven by a worm gear. A crank attached to the axis of this gear has a finger which is inserted in the holes of a divider platform.

It is thus seen that the angle by which the spindle turns depends upon:

1. The accuracy of the holes in the platform.

2. The precision in the cutting of the wheel and worm gear.

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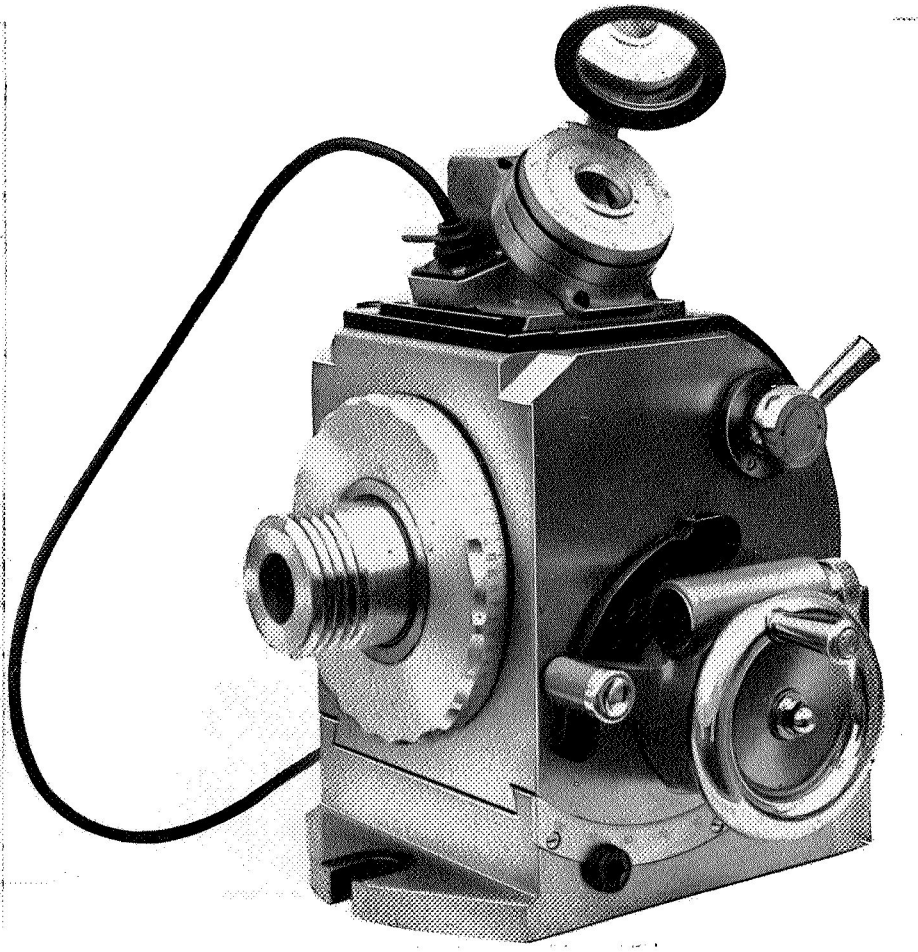

Figure 1. Exterior View

The tolerance in the angle as measured by such a mechanical divider is generally 1'. Unfortunately this precision cannot be evenly maintained since, depending on the nature of the work done, the teeth do not wear equally.

In optical dividers, a divided drum is secured directly on the main spindle. The angles of rotation are read through an optical device attached to the body of the instrument. The pair wheel and worm gear are still present, but serve only as transmission members which do not influence the precision of the reading.

The fragile optical parts are enclosed by strong casings, and the optical dividers are therefore less delicate to handle, and no more fragile than mechanical dividers. They are not only precious instruments for the metrology laboratory, but also excellent tools for machining work as shown by the following instructions.

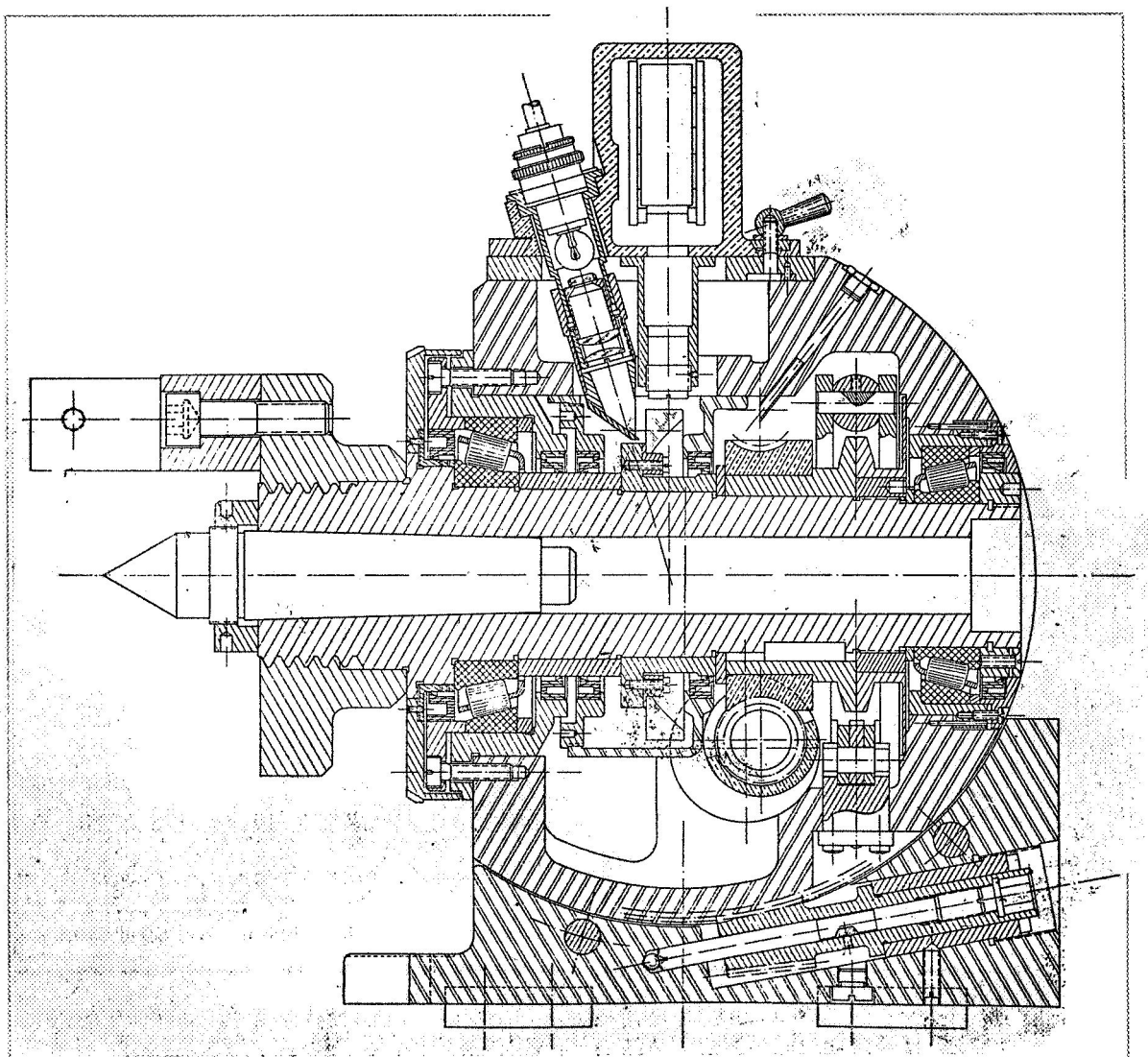

Figure 2. O.P.L. Divider

Longitudinal cross-section showing the spindle assembly, the device illuminating the drum, the collar for the lock, and the tilt mechanism.

Description of the O.P.L. Optical Divider (Figures 2, 3 and 4)

Spindle

The spindle is mounted on two strong Timken, high precision, conical bearings. A preload of the order of 500 kg is applied during the assembly

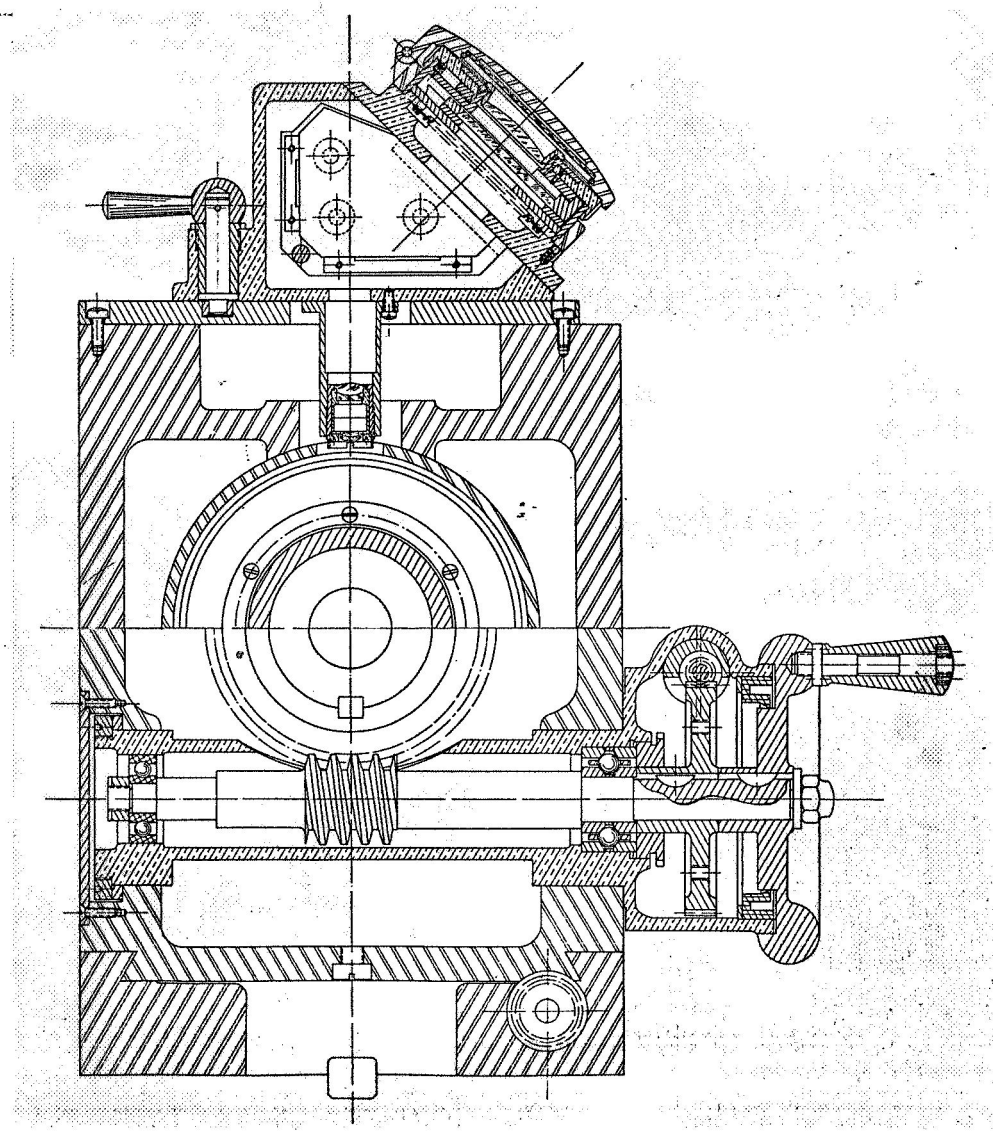

Figure 3. O.P.L. Divider

Transverse cross-section. The top part is a cross-section through the measurement optical system. The eccentric for the blocking mechanism is also shown. The lower part is a cross-section through the drive shaft showing the speed reduction system.

to give the spindle a considerable degree of rigidity and to exclude any possibility of play. The spindle has a perfectly centered Morse conical center No. 4, and a standard threaded nose.

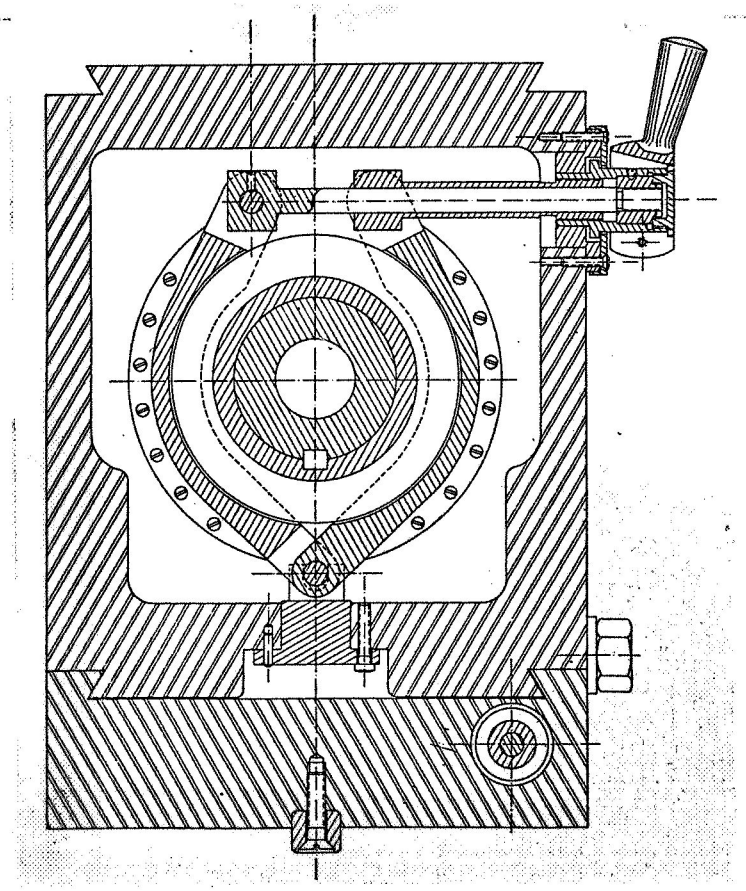

Figure 4. O.P.L. Divider

Transverse cross-section. Notice the mechanism for driving the jaws of the spindle brake and the parts for blocking the head inclination.

Drive Mechanism

The highly resistant hollow bronze wheel is anchored to the spindle. The worm gear, made of treated and corrected steels, is mounted on bearings so that its operation is very smooth. The worm gear is mounted on an eccentric and can be disengaged by a hand operated clutch, which allows a rapid rotation of the spindle to be performed by hand; this is a considerable advantage when the machine part is to be centered.

In the engaged position, the worm gear is driven for normal operation by a wheel which is anchored to it. In order to perfect the readings, the operator has at his disposal a knob which, by reduction, drives the worm gear through a pair of helicoidal gears located under the casing. A turn of the knob rotates the spindle by 1 degree.

Reading Mechanism

The device used here is analogous to the "O.P.L. Micrometric Indicator". The graduation, as made on an optically treated drum, is illuminated by a low voltage bulb and condenser, and is projected in magnification on a ground glass by a microscope objective. The angle is read directly on the ground glass in degrees; the finer measurement in minutes and seconds is made in the following way.

The two marker lines engraved on the ground glass are moved to exactly frame the image of the divider line, by an engraved knurled ring located around the ground glass.

The circle dial engraved in minutes of arc and a vernier permits the reading of the spindle rotation angle down to 5". Since the framing by the two marker lines can be done in only one way, no reading error is possible. This reading system presents the following advantages over the standard microscope device.

1. Since the reading is performed at a distance of normal vision there is no fatigue from eye accommodation, as in the case of microscope readings.

2. The operator does not have to come close to the moving parts of the machine while keeping visual control of them, thereby reducing the chances of accidents.

Locking Mechanism

The reading assembly can move along a transverse slide which allows selection of a convenient origin for the series of measurements to be made. An external auxiliary drum, divided into degrees, is friction-connected to the nose of the spindle, and serves to give a rough measurement of the angle of rotation.

Spindle Locking Assembly

If, after a precise reading of the angle, the part must be worked on while held in the previously determined position, it is necessary to completely lock the spindle to prevent turning. It is therefore obvious that a mechanism is necessary for firmly locking the spindle, which will not impart to the latter any diametrical, longitudinal or rotational reaction, since this would impair the precision of the angle measurement.

The O.P.L. system is constructed from two truncated cones, one anchored to the spindle, the other connected to the head by a side plate

which is longitudinally flexible but extremely rigid rotationally. Two articulated half-collars operated externally with a lever ensure a strong lock on the whole circumference of the brake.

Inclination Device

The head of the divider is mounted on the base through a circular slide. It can move back and forth so that the spindle can take the vertical position. A worm gear is operated by a key, after releasing the slide brake, and facilitates the reading made from a dial with a vernier giving 1'.

Accessories

The accessories are:

1. An accessory center adjustable in height and inclination (when off-center, this centerpiece permits a slight transverse adjustment if the shims are no longer sufficient to handle the wear of the machine table),

2. A faceplate for holding a dog,

3. An anchorplate mounted on the nose of the spindle,

4. A center,

5. Keys for servicing the instrument,

6. Spare light bulbs,

7. A transformer of $\frac{115\text{-}125 - 220\text{-}240}{6}$ volt ratios supplying the current.

INSTRUCTIONS

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Unpacking the Instrument

The instrument and its accessories are contained in a hardwood case and arranged as shown in Figure 5.

After removal of the cover, the main head of the divider is found to be locked in a wooden slide by two nuts. We recommend the divider be secured in this way before carrying it to avoid any possible damage during transportation.

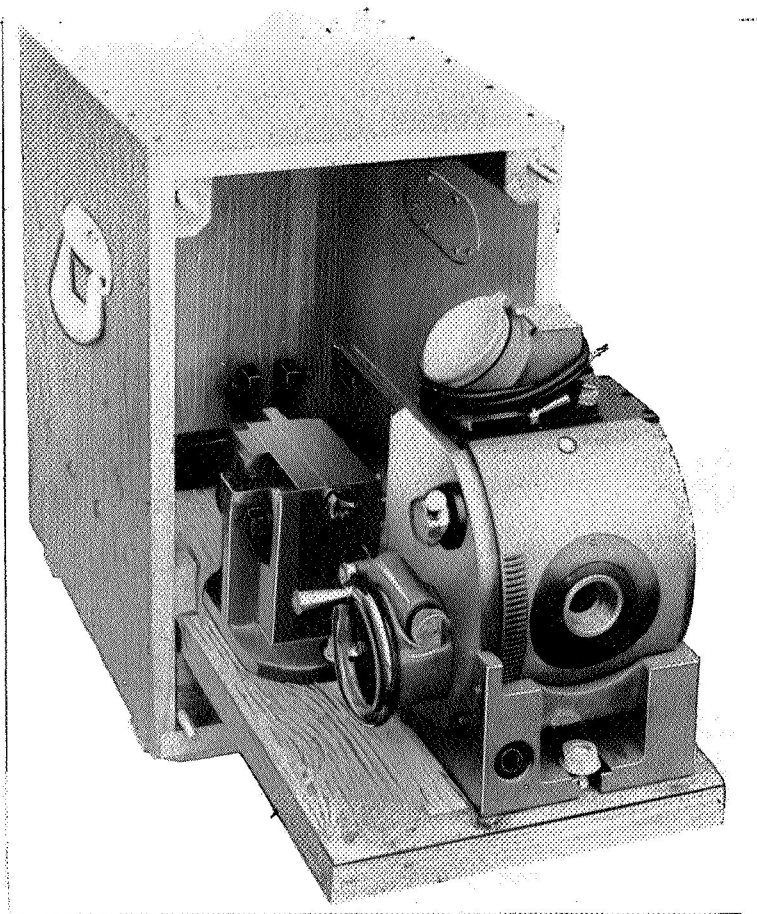

Figure 5. Arrangement of the Divider and Accessories in the Case

Positioning on the Machine

Carefully clean the rest surfaces of the divider and of the accessory center if necessary. Clean the machine table and remove the chips which might remain in the T slots.

Position the divider by correctly engaging the shims in the slots. If necessary, place the shims on one side of the slot and maintain them in this position while the bolts are tightened.

Adjustment of the Spindle Inclination

With the hex key, slightly loosen the two lock screws which are accessible from the side where the drive wheel is located. With this key, turn the adjustment screw, which is accessible from the rear side of the

spindle, until the inclination dial (from -5° to +90°) indicates the desired angle. Then tighten the two lock screws.

Using and Positioning the Accessory Center

If the spindle of the divider must remain horizontal, so must the center. If the divider is tilted (within the limits tolerated by the accessory center), the accessory center should be tilted in the opposite direction by the same amount. The accessory center should be separated from the divider head so that the part may be tightened during the adjustment.

If there is play between the shims and the slots while the bolts are being tightened, the slots should be placed against the same face as for the divider. Then make sure that the center and the axis of the divider are aligned by the following method.

1. With a comparator indicator, make sure that the centerpiece, which is mounted on the divider, is well centered by matching the marks on the centerpiece to the marks on the spindle. If this centerpiece is not centered properly, disassemble it and ensure that it is clean. If, after a few trials, the centerpiece is off-center more than 2 microns, the centerpiece must be corrected.

2. When the centerpiece is properly centered, attach a plate to the nose of the divider (the anchorplate furnished with the divider for example). Check the indicator while revolving the spindle to ensure that this plate does not run out. (If they are properly mounted on the spindle, the plates furnished with the divider do not have more than a 4-micron runout.)

3. Mount between the centers a mandrel the same length as the machined part. In most cases, the part itself is sufficient for this operation. Attach an indicator to the part or mandrel with a support and clamp, which are generally furnished with the comparators as shown in Figure 7.

If the indicator needle remains steady during the rotation, proper alignment exists. Otherwise, by comparing the two positions 180° apart, successively adjust the centering in widths (the support of the indicator being horizontal), and in height (the support being this time vertical).

Horizontal adjustment is accomplished by rotating the eccentric centerpiece. Vertical adjustment is accomplished by turning the height adjustment screw after the blocking screws have been loosened. Check to be sure that this adjustment is maintained after retightening.

Of the two blocking screws, only the one located on the divider head stops the centerpiece from sliding. It is therefore necessary to keep the blocking screw, which is located on the drive side, tightened after adjusting the tilt and height. Otherwise the latter could be destroyed when the part is removed.

Note: It is better to adjust horizontally before adjusting vertically because the former reacts slightly on the latter since it is performed with the centerpiece off-center. A calculation, which cannot be proven here, shows that a 1/100-mm comparator indicator is quite adequate for this adjustment.

Centering of the Machined Part

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Whether the part is held between the centers or not, it must be perfectly centered on the divider's axis of rotation. For example, this is the case when a pinion is mounted on a mandrel, which must be perfectly centered (Figure 6).

Consider a circular disk with a center O and assume that it is accidentally mounted on a divider which has an axis of rotation of O' with

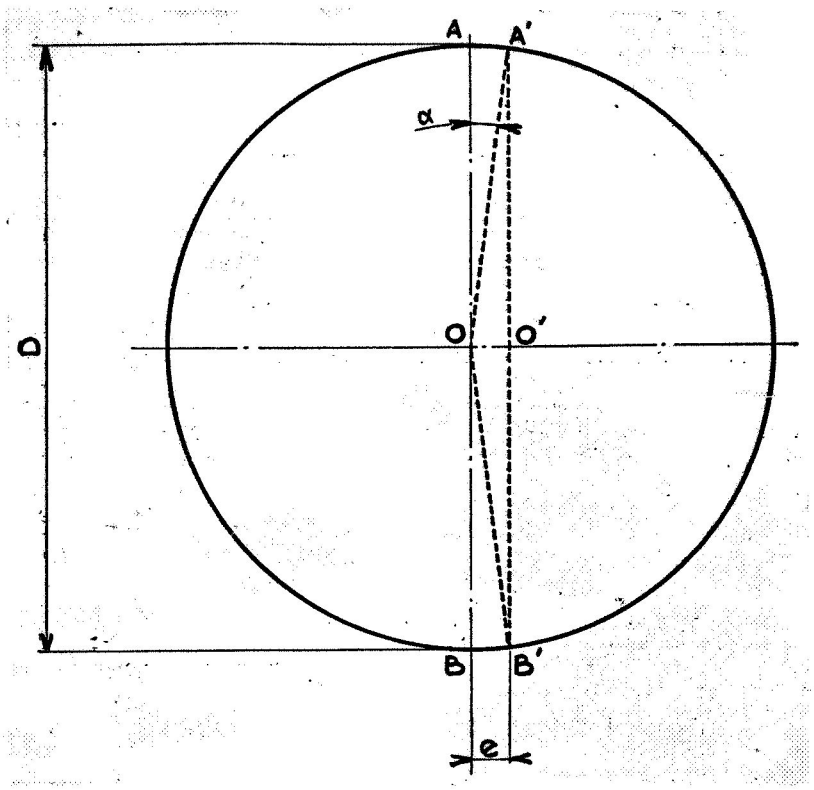


Figure 6

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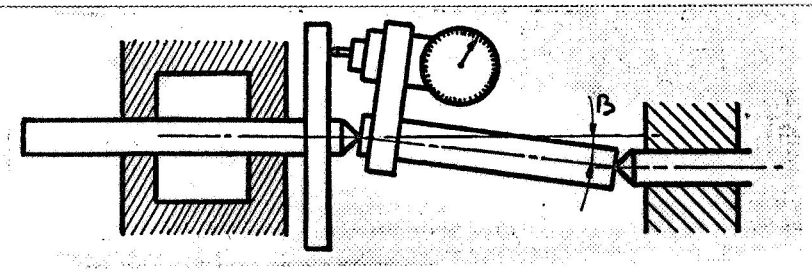


Figure 7

an off-center value e (eccentricity). The diameter of the disk is D. Make a mark with a tool on the disk at A'. After the divider has been rotated 180°, mark at B'. If the disk is perfectly centered, the corresponding marks would be A and B, respectively.

Let AOA' = BOB' = $\alpha$.

It is obvious that the maximum overall error in the division will be:

$$AOB - A'OB' = 2\alpha.$$

Since $\alpha$ is very small, it can be written as $\alpha = \frac{2e}{D}$ radians

or, in seconds, $\alpha'' = \frac{2e}{D} \times 206{,}000''$,

maximum error = $2\alpha = \frac{e}{D} \times 824{,}000''$.

An example is a 100-mm pinion which is to be cut. The indicator shows an off-center of 1/100-mm, which corresponds to an eccentricity of 0.005.

$D = 100$ $\qquad$ $e = 0.005$

Maximum error = $\frac{0.005}{100} \times 824{,}000$ or 41" approximately.

This error of 41" is much greater than the precision guaranteed for the instrument. We conclude therefore that, for best results, the center adjustment must be checked with an indicator good to within one micron.

Lighting

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The lighting is accomplished by a low-voltage bulb which is fed by a transformer. The transformer primary is connected to the mains through

a standard extension cord. A spindle type fuse enables the transformer to be set to the mains voltage by changing its position (115-125 - 220-240 volts).

Before connecting the transformer, make sure that the fuse is in the position which corresponds to the mains voltage. A small plug connects the bulb to the transformer secondary. The bulb socket is secured to the divider by a knurled ring and can be removed by a few turns.

The bulb is a common type; 6 volts, 0.35 amperes. Its filament must, however, be centered on the optic axis of the lighting system. This is the reason why we furnish these bulbs on specially centered rings.

To change a bulb whose filament is burned or broken, the bulb must be unscrewed together with its centering ring and replaced by one of the spare bulbs centered on their respective rings.

Note: For customers who have on their machines a safety lighting system operating at 24 v., we are able to furnish them with bulbs for their centering rings for 24 v. operation upon request.

Reading

Two cases are possible:

a) The part is oriented by the marks made on the part itself, by a reference faceplate, by teeth, etc., and the angle is to be read (this case is very frequent in control operations).

Bring the two ground glass marks to frame exactly the projection of a division mark by turning the knurled ring located around the ground glass. The number located in front of the framed division (142 on Figure 8) is the coarse reading. The reading from the dial and vernier (32'15" on the same figure) is the fine reading in minutes and seconds.

b) After a certain operation is performed the part must be rotated to show a new angle (this is the case usually encountered in machining operations).

Rotate the knurled ring to show the minutes and seconds with the vernier, regardless of the position of the projected image of the division.

Turn the spindle with the drive wheel while observing the coarse dial mentioned before (not the optical dial). Obtain roughly the numbers of degrees wanted. With the reduction knob bring the image of the selected division projected on the ground glass to lie halfway between the

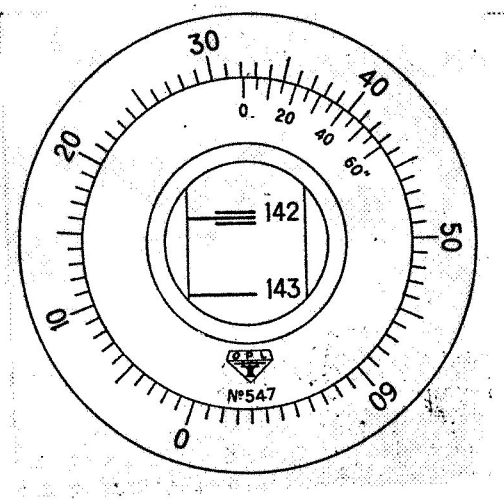


Figure 8

two marks. When normal divisions must be performed the angles which are listed on the tables furnished with the divider should be the ones shown (division of the circle into 2, 3, 4, ..., 200 parts).

Resetting Operation

Sometimes in the control operation or machining of a part the origin of the angles is not arbitrary, but is connected with a faceplate, a hole, a reference notch, a tooth, etc. Since it is difficult to orient the part rigorously during the tightening of the dog or the anchoring of the part, the orientation will be done to within approximately $1^{\circ}$.

Next, with a slow motion, bring the part to its origin position (reference faceplate horizontal, for example), then loosen the screw securing the resetting slide and rotate the drive for this slide until the origin angle (usually $0^{\circ}$) is indicated. Then relock the resetting slide. Rotate by hand the coarse dial which is friction-connected to the spindle to have agreement in reading with the measurement division. The remaining operations can be performed regardless of the initial origin setting.

Disengaging the Worm Gear

When the machined part has to be centered with the comparator, it may become tiresome to rotate the worm gear 40 turns for every turn of the part. /11

To disengage the worm gear, press the locking button located at the end of the clutch lever. Lower this lever until the lock is triggered. The spindle is now free to rotate.

To re-engage the worm gear, press on the locking button and pull the lever gently so as to avoid damaging the teeth of the wheel. Slowly rotate the gear so that its threads engage into the teeth of the wheel. Pull the lever again until the lock triggers.

Locking

During a machining operation the machine tool acts on the part and can transmit a vibration on the spindle within the tolerated limits of play and bending of the teeth of the worm gear and wheel. It is therefore important, after having obtained an angle reading, to prevent the spindle from rotating by means of the lever located above the drive wheel. This locking must not produce any reaction in rotation; this can easily be verified by making sure that the division mark is still correctly in place between the two ground glass marks. Do not force the drive wheel if the lock was forgotten in the locked position.

Lubrication

If the divider is constantly used, a few drops of average viscosity oil every week are enough to lubricate the wormgear-wheel pair. This oil must be inserted by a "Lub" type pump into the greaser which is designed to do the job.

Once a year remove the plug located under the head of the divider in order to eliminate the excess oil which, if it remained in too great a quantity in the casing, could spot the division drum. Easy access to the plug can be obtained by tilting $40^{\circ}$. Also once a year disassemble the drive wheel and change the grease which is contained in the reduction casing. Occasionally a few drops of oil on the crankshaft and on the tilt dial will complete the lubrication care of the instrument. Do not lubricate the reading system.

Various Adjustments

Since the spindle bearings are preloaded and since they perform little work, they require no adjustment.

If, after extended use, the wormgear-wheel pair has a significant play, loosen the screws holding the locking component. Remove the positioning pins and rotate the locking component in a counterclockwise direction around the axis of the drive wheel to compensate for the play. Then tighten the screws above.

To compensate for the play of the reduction knob, loosen the plug opposite the knob and rotate the off-center socket located at the end of the knob until the play is compensated. Tighten the plug moderately. This operation should be done fairly gently.

If the brake has some wear it may become possible for the lever to fall into an inconvenient position to perform the locking. To remedy this, loosen the split collar which is part of the lever and re-orient it in a convenient position and tighten the screw. No other adjustment is needed when the instrument is used normally.

If, after many years of use, a complete checkup is necessary, we advise that the instrument be returned to the manufacturer or to a franchised representative.

Prepared for the National Aeronautics and Space Administration by John F. Holman and Co. Inc.

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